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(54) **Spray drying system**

Sprühtrocknungssystem

Système de séchage par pulvérisation

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(ICHIROU TSUTSUI) 28 February 1983
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Description

Field of the Invention

[0001] The present invention relates to chemical processing equipment, in particular, to systems for converting into a uniform powder a liquid feed which consists of a solution or suspension of particles in a fluid medium.

[0002] More particularly, the invention relates to so-called spray drying systems for drying by evaporation of a fluid medium from the liquid feed, after the feed is atomized and converted to the form of a cloud of fine droplets with a large exposed surface. During evaporation the fluid medium becomes a vapour which is evacuated from the system; the particles which have been separated from the fluid medium fall from the cloud in the form of a powder which can be collected from the system.

Background of the Invention

[0003] Chemical processing plants for the drying of a liquid feed by means of its spraying and evaporation have been known and successfully practiced in special applications, particularly for the preparation of aluminous porcelains, since the last quarter of the nineteenth century.

[0004] Since the beginning of the twentieth century extensive application of the spray drying process in a wide variety of industries has been evident, e.g., in drying milk, soaps, detergents, pharmaceuticals, organic and inorganic chemicals, etc.

[0005] There are many known engineering monographs describing this process and its peculiarities with respect to the spraying equipment design. An example is W.R. Marshall's *Atomization and Spray Drying*, published by the American Institute of Chemical Engineers, 1954, or *Ceramic Monographs - Handbook of Ceramics*, 1980 Verlag Schmid GmbH.

[0006] The basic principles of the spray drying process include preparation of the liquid feed, which is then atomized into a spray. This spray, presented as a cloud of fine droplets, is projected into a stream of a hot gas which is contained within a cylindrical chamber with a conical or flat base. Drying by evaporation from the large exposed surface of the spray is rapid, and the vapour driven off is extracted from the chamber by means of cyclones, wet scrubbers or other appropriate equipment. The drying process is terminated when moisture content in the dried particles is reduced to the desired value and the particulated product is discharged from the chamber.

[0007] One of the additional advantages of spray drying systems is associated with their versatility in that they operate both in a continuous cycle without interruption as long as wet feed is supplied, as well as in a batchwise manner if so desired.

[0008] The main disadvantage of spray drying equipment implementing the transfer of heat energy to liquid feed by means of direct contact with hot gas is associated with the fact that it is usually suitable only for those materials which are not heat sensitive or readily oxidized, like minerals, inorganic oxides, bentonite, calcite, etc. For some materials, like some foodstuffs, pharmaceuticals, penicillin, blood plasma, and many others, this way of heat transfer is unsuitable, and spray dryers which employ hot gases or other means that come in direct contact with the dried feed, cannot be utilized.

[0009] It is common to dry heat sensitive or oxidizable materials by means of indirect batch dryers in which heat is transferred to the wet material via a retaining wall, and there is no contact between the vaporized liquid medium and heating medium. An example of these dryers is the so-called agitated pan dryer which operates atmospherically or under a vacuum, and usually handles only small amounts of nearly any wet solid, that is, liquids, slurries, pastes, etc.

[0010] Another common type of indirect dryer suitable for processing heat sensitive materials is the freeze dryer in which wet material is frozen prior to drying. Since it is necessary to maintain a very high vacuum when drying in the frozen state, freeze dryers are rather expensive installations due to the complex and sophisticated vacuum systems which they employed. Use of this type of dryer is, in most cases, limited to pharmaceuticals, fine chemicals and other related products which cannot be dried by any other means.

[0011] Another type of indirect dryer which is applicable for heat sensitive materials is the vacuum rotary dryer or vacuum shelf dryer. In vacuum rotary dryers the wet material is agitated in a horizontal stationary shell, the vacuum not always being necessary. In vacuum shelf dryers there is no agitation; the wet material is heated by contact with steam-heated or hot water-heated shelves on which the material lies.

[0012] The main disadvantage of indirect dryers is their basically reduced efficiency in terms of output which is associated with the batch mode of operation. Because of the long holdup required for internal diffusion of heat or moisture, a long heating cycle is necessary for achieving the desired moisture content.

[0013] There is also known method of producing a thermoreactive resin moulding material which is described in the Japanese laid-open patent application (Kokai) No. 58-13634 assigned to Matsushita Denki Co., Ltd. This method includes the step of spraying water-soluted urea resin syrup under low pressure with the simultaneous dehydration by heating of the condensation polymer. The drying system implementing this method includes a dehydrator in which the preheated syrup is sprayed by nozzle, and evaporates by virtue of the heat, supplied to the interior of the dehydrator via its walls. The moisture and solutes are evacuated from the dehydrator by a vacuum pump, leaving the dried urea resin which is collected in the lower part of the dehydra-

tor in the form of particles.

[0014] Moisture and solutes are evacuated via an outlet port supplied in the side wall of the dehydrator in the vicinity of the spraying nozzle. The disposition of the outlet opening for evacuated moisture close to the spraying nozzle might be associated with certain limitations upon the relationship between the velocity submitted by the spraying nozzle to the atomized feed and the velocity submitted by the vacuum pump to driven-off solutes.

[0015] If the velocity of particles moving together with the sprayed feed via the heating zone towards the lower part of the dehydrator is too slow, or the velocity of the driven-off solute is too fast, the major part of the feed might be driven off by the pump from the dehydrator before the drying process has been completed. This situation might arise, e.g. when the feed is atomised into very fine particles by the ultrasonic nozzle, since the ultrasonically atomized spray moves with a velocity of several tenths cm per second, while the solute, driven off by the vacuum pump, moves with faster velocities by an order of magnitude.

[0016] This assumption is supported by the indication which can be found in this application, that the final product collected in the bottom of the dehydrator consists of relatively coarse, 60 mesh particle size, particles. It should therefore be concluded that the drying system disclosed in the Japanese application inevitably becomes limited to only a certain type of atomizing means and therefore to a particular size of final product, ensuring the optimal ratio between velocities of sprayed feed and driven-off solute.

[0017] JP-A-5834002 discloses spray drying apparatus comprising a drying chamber, means for supplying hot air to the drying chamber, a pump for pumping into the drying chamber a suspension of fine particles in a liquid and an ultrasonic sprayer for atomizing the liquid as it enters the drying chamber. Coarse dry particles collect in the container at the bottom of the chamber whilst hot air, vapour and fine particles are drawn by a suction fan from the drying chamber at an intermediate level therein and pass through a series of cyclone separators, for removal of the dried fine particles, these cyclone separators being disposed downstream of the drying chamber and upstream of the suction fan.

[0018] EP-A-341580 discloses apparatus for the distillation of mercury containing liquids. The distillation process is carried out within a processing chamber, into which the mercury-containing liquid is fed by means of a rotating sprayer. The liquid is heated before entering the processing chamber. Furthermore, the heating chamber is provided with indirectly heated walls, so that separation of mercury in the form of dry residual is effected by direct contact between the thin film of mercury-containing liquid and the hot surface of the walls. A rotating scraper collects dry residue and directs the residue to the bottom of the chamber. The drying chamber is connected with a vacuum pump capable of reducing the

pressure within the chamber so as to cause boiling of the liquid phase at a temperature lower than the boiling point of mercury.

[0019] It is among the objects of the present invention to provide a spray drying apparatus in which the above-mentioned drawbacks are sufficiently reduced or overcome.

[0020] In particular, one object of the present invention is to provide an apparatus for drying wet material, which constitutes a solid phase distributed in a fluid medium, by means of evaporation of said medium at reduced pressure or at vacuum so as to achieve the possibility of drying heat-sensitive or readily oxidizable materials at lower temperatures than those needed for evaporation of fluid medium at normal pressure, thus preventing deterioration of their properties.

[0021] Another object of the present invention is to provide a spray drying apparatus which operates with increased efficiency in drying and reduced moisture content in the final product.

[0022] A further object of the present invention is to provide a spray drying apparatus which has simple construction and is therefore reliable and easy to maintain.

[0023] Still a further object of the present invention is to provide a spray drying system which is suitable for drying the wet materials presented in different initial condition, i.e. solution, suspension, dispersion, paste, slurry, sludge.

[0024] According to the present invention, there is provided apparatus for drying wet material constituting a solid phase distributed in a fluid medium by means of evaporation of said medium, said apparatus comprising:

a feeding means adapted to supply said material in liquid state into the system, e.g. in the form of a solution, suspension, dispersion, or prepared from a paste, slurry, sludge,

a means of atomisation adapted to spray the supplied liquid material so as to convert its initial state into a mist consisting of a plurality of droplets, an indirectly heated chamber adapted to evaporate the fluid medium from said mist of droplets generated by said means of atomisation,

a product collecting means adapted to collect the solid particles of the final dried product, produced from said wet material, recovery means to recover said fluid medium from its evaporated state,

a vacuum pump communicating with the interior of said heating chamber, adapted to maintain reduced pressure in the interior of said heating chamber so as to evaporate said fluid medium at temperatures lower than needed for its evaporation at normal pressure, and to evacuate, from the heating chamber, the moisture vapour generated during evaporation of said fluid media

the heating chamber being formed as an elongated compartment provided with vertical side walls and having top and bottom extremities, said atomisation

means being mounted adjacent to the top extremity of said chamber, said recovery and product collecting means being mounted adjacent to the bottom extremity of said chamber, characterised in that said product collecting means comprises a collecting bag or cyclone system and said vacuum pump communicates with the interior of said heating chamber through said collecting bag or through said cyclone system, said recovery means to recover said fluid medium including means connected between said vacuum pump and said product collecting means, and in that a vapour sweeping means is provided formed as a hollow tubular element mounted within said heating chamber and extending longitudinally close to the wall of the heating chamber, said tubular element being connected with said vacuum pump, the hollow tubular element being provided with a plurality of openings providing communication between the interior of the heating chamber and the interior of said tubular element, whereby part of the vapour generated within the heating chamber during evaporation of the spray can be swept off through said tubular element, the apparatus including display and control means provided with appropriate sensors and instrumentation to control process variables.

[0025] Preferably, said atomization means is formed as an ultrasonic oscillator consisting of a nozzle connected to a generator of ultrasonic vibrations and said nozzle is provided with an elongated horn portion which applies vibratory motion at the free end thereof to the liquid material supplied by said feeding means.

[0026] The ultrasonic oscillator is preferably mounted at the top extremity of said heating chamber, said elongated horn portion being oriented parallel to the longitudinal axis of the heating chamber.

[0027] In one embodiment said feeding means supplies the liquid material from the outside to the free end of said horn portion.

[0028] In another embodiment said feeding means supplies the liquid material *via* said nozzle to the free end of said horn portion.

[0029] Preferably, the system is provided with an additional collecting and recovery means and said vapour sweeping means is connected with said vacuum pump *via* said additional collecting and recovery means.

[0030] Preferably, said vapour sweeping means is formed with a plurality of shields, mounted on the outwardly facing surface of said hollow tubular element in the vicinity of said openings so as to provide a separation of particles of the final product from the vapour generated during evaporation and driven off by said sweeping means *via* said openings.

[0031] The present invention in its various embodiments has only been briefly summarized. For a better understanding of this invention, as well as of its advantages achieved by virtue of the above-mentioned

embodiments, reference will now be made to the following description which is taken in combination with accompanying drawings.

Brief description of the drawings

[0032]

Fig. 1a is a general schematic view of a spray drying system showing its main components and a block-diagram illustrating its functions. This system is not in accordance with the invention.

Fig. 1b shows a pressure-temperature relationship which corresponds to liquid-vapour equilibrium transition for water, implemented in the spray drying system, according to the present invention.

Figs. 2a,b show a different disposition of the atomizing means with respect to the longitudinal axis of the heating chamber. This system is not in accordance with the invention.

Fig. 3 presents a diagrammatic view of a spray drying apparatus equipped with moisture vapour sweeping means according to the invention and an additional collection and recovery means.

Figs. 4a,b show an enlarged view of detail I encircled in Fig. 3 and enlarged partial view of the vapour sweeping means shown in Fig. 3.

[0033] With reference to Fig. 1a the system comprises feeding means 1, which supplies liquid material into interior 2 of the heating chamber 10 in which evaporation of the liquid takes place. The feeding means is substantially formed as a closed container equipped with a pump (not shown) for direct supply of the feed to the heating chamber through the appropriate piping line or to atomization means 5 by gravitation via a slanted pipe line 4.

[0034] It might be advantageous to provide the feeding means 1 with the appropriate heating or cooling device and/or agitator so as to control the temperature inside the container and to adjust viscosity of the feed before it is supplied to the chamber. By virtue of such an arrangement better atomization might be ensured, as well as the possibility for drying materials with various initial physical conditions, e.g., solutions, suspensions, dispersions, pastes, sludges, slurries, etc. Piping line 4 might be provided with a regulating valve 6, mounted adjacent to the outlet opening of the container so as to enable control of the feed rate to the liquid material being supplied to atomization means 5.

[0035] Liquid material after it is atomized is dried inside the main heating chamber 10, which is preferably formed as a cylinder with longitudinal axis X-X. The hollow interior 2 of the chamber is defined by inner wall 20, upper flange 22 and lower flange 24.

[0036] The interior of the heating chamber is divided into the upper extremity 21, situated adjacent to the atomization means 5, central heating zone and lower

extremity 23, which communicates via sliding gate 25 with dry collecting means 26. The heating chamber is provided with heating elements, preferably formed as a spiral 27, coiled around the outwardly facing surface of cylindrical wall 20. The heating elements are connected with the appropriate power supply (not shown) so as to provide indirect heating of dried material inside the heating chamber by means of heat transfer via chamber wall 20.

[0037] It is preferable to arrange heating elements along the entire length of the cylindrical wall of the chamber and divide them into groups so as to provide independent local heating of different zones of the heating chamber along its longitudinal axis X-X. An insulation layer 28 closes heating spiral 27 so as to prevent loss of heat to the outside.

[0038] It should be understood that instead of spiral heating elements, an alternative means, suitable for indirect heating, can be provided, e.g., infrared heaters, steam-heated jacket, etc.

[0039] The inner wall of the heating chamber is made from appropriate heat-resistant material, e.g., stainless steel, glass, refractory ceramic or their combination.

[0040] The atomizing means 5, employed in the drying system is preferably formed as an ultrasonic oscillator 50 which is connected to a generator of ultrasonic vibrations 51. It is preferably that the oscillator be joined with a nozzle.

[0041] By virtue of ultrasonic vibrations submitted to the liquid feed by the nozzle, the feed, which was initially presented in continuous liquid form, becomes a spray which consists of a plurality of tiny discrete droplets constituting a mist, characterized by a very large surface.

[0042] Oscillator 50 is provided with an elongated horn portion 52 which submits a vibratory motion at its free end 53 to the liquid material supplied to the nozzle by said feeding means. Fig. 1a shows the supply of liquid feed to the free end of the nozzle from the outside container by means of piping line 4; however, it should be understood that the feed can be supplied to the free end of the horn portion via the through-going passage-way formed in the oscillator itself as well.

[0043] Oscillator 50 can also be provided with an appropriate polarization means which submits an electrostatic charge to the spray droplets, thus enabling better control of spray pattern geometry.

[0044] Arrangement of polarization means as well as appropriate means for its control can be carried out according to known techniques e.g., as described in Rudenko's Russian patent SU 978934 or PCT application US87/02159.

[0045] Figs. 1a and 2a show the coaxial disposition of the spray nozzle 50 with respect to the longitudinal axis X-X. By virtue of this disposition the geometric spray pattern achieved is schematically shown by the dotted lines in Fig. 2a.

[0046] It might be advantageous if the nozzle disposition is chosen as in Figs. 2b and 3. In accordance with

this arrangement oscillator 50 is situated inside the auxiliary heating compartment 100 located at the upper end of the main heating chamber 10. Compartment 100 extends radially with respect to the main heating chamber; its interior 2' communicates with the interior 2 of the main heating chamber by means of neck portion 150.

[0047] The auxiliary compartment 100 might be provided with heating elements 270 mounted outside its interior 2' so as to enable indirect initial heating of the atomized spray, before it reaches heating chamber 10.

[0048] As can be seen in Fig. 2b, oscillator 50 is slanted with respect to the longitudinal axis X-X of the main heating chamber in the sense that the elongated horn portion 52 of the nozzle tip defines a certain acute angle α with this axis.

[0049] The spray coming out of the ultrasonic oscillator is atomized into fine droplets, their size varying between 10 and 100 μm (microns) depending on the power supplied by the generator to the oscillator.

[0050] This spray enters the auxiliary heating compartment and after that proceeds downward into the main heating chamber. The geometry of the spray associated with this arrangement is shown by the dotted lines in Fig. 2b. It can be easily understood that by changing the angle α , this geometry can be varied so as to ensure the most efficient spraying of feeds, the initial liquid condition of which is characterized by different viscosities.

[0051] It should be also understood that ultrasonic oscillation is not the only suitable method for atomizing liquid feed; alternative embodiments of the atomizing means can be employed in the drying system according to the present invention, e.g., a spinning disc centrifugal atomizer. The method of employing two fluid spray atomizers can be used as well.

[0052] Atomized spray in the form of a mist is heated inside the heating chamber, and the fluid media is evaporated from the mist droplets while the dried solid particles of the final product, with desired residual moisture, fall down from the mist towards the bottom extremity 23 of the heating chamber. They are discharged with the collecting means 26, situated adjacent to the bottom extremity of the heating chamber.

[0053] As can be seen, the collecting means is arranged at a considerable distance from the atomizing means so as to ensure sufficient residence time for the product moving from the heating zone to discharge zone.

[0054] As a suitable collecting means, one can use a removable fabric bag filter arranged on a bag house (not shown), cyclone filter or their combination. To enable removal of the full bag from the housing and discharge of the collected powder, sliding gate 25 is closed so as to evacuate interior 2 of the heating chamber from the collecting means.

[0055] The fluid media evaporated from the liquid material is driven off by virtue of an appropriate evacuation means as will be explained later. This media, in the

form of a hot moist vapour, proceeds via the collecting means 26 into the recovery means 31, where it is transferred back to the liquid state and can be taken out of the system via outlet valve 32 which is installed in the conical bottom part of the recovery means. It might be advantageous to combine components 25, 26 and 31 into one modular unit 250 which will enable both product collection and recovery of the liquid media.

[0056] A condenser with liquid cooling agent, or wet scrubber is an example of an appropriate recovery means which can be employed in the drying system, according to the present invention.

[0057] The bottom part of the recovery means is provided with outlet port 33, communicating via valve V1 and piping line 34 with evacuation means 40.

[0058] The purpose of evacuation means is twofold: to maintain reduced pressure inside the heating chamber and to exhaust the moisture vapour generated during evaporation of the fluid media, which was not recovered inside the recovery means.

[0059] With reference to the diagram shown in Fig. 1b, it will now be explained how, by virtue of the reduced pressure maintained inside the heating chamber due to evacuation means 40, it is possible to evaporate the fluid media from the wet product at temperatures which are lower than would be needed to evaporate this media at normal pressure.

[0060] This diagram shows that water can be brought to boiling point at temperatures below 100 °C, if the pressure of its vapour is less than standard atmospheric pressure of 1013 millibar (760 torr). This well-known phenomena is known as liquid-vapour equilibria phase transition, and it is exhibited by many other liquids as well.

[0061] By means of reduced pressure maintained in the chamber, drying heat sensitive materials becomes possible without deterioration of their properties, since evaporation of the liquid solvent takes place at reduced temperatures.

[0062] It has been empirically found that for drying of heat sensitive materials, employing water as a fluid media it would be preferable for maintaining reduced pressure, in the 26-200 millibar (20-150 torr) range, in the heating chamber, and therefore to perform drying at temperatures below 25-60 °C, instead of 100°C.

[0063] For maintaining such a level of reduced pressure, very simple and compact equipment, such as vacuum pump or any other suitable mechanical pump, can be used. It should be pointed out that known drying systems which employ a vacuum, e.g., freeze drying, require a vacuum in the range of approximately 1.3-0.13 millibar (1-0.01 torr), which is associated, with necessity, to complex and expensive vacuum producing installations which demand a large amount of space.

[0064] Output capacity of evacuation means and level of reduced pressure inside the system can be adjusted by regulating valves V1,V2, installed correspondingly in piping line 34 and adjacent to pressure gauge 42.

[0065] In order to eliminate leaks and maintain the required level of reduced pressure in the system, all connections between the chamber and other components, as well as connections between the components themselves, should be properly gasketed and sealed.

[0066] Pressure gauge 41 is arranged in the upper flange of the chamber so as to enable measuring the level of reduced pressure maintained in the chamber; pressure gauge 42 checks the pressure in piping line 34.

[0067] Aside from the pressure gauges, the system has other relevant instrumentation which is required for its proper functioning, in particular, with contact thermometers and thermocouples for measuring temperatures in the feeding container, at the nozzle, in different zones of the heating chamber, and inside the collecting and recovery means.

[0068] Also provided is a computer control system 60 connected to outputs of all instrumentation items via interface 61. The computer system is also wired to the ultrasonic vibrations generator 51, the regulating valves V1, V2 and with the central instrument display panel 62, which is equipped with a switchboard, enabling coordinated control of the functioning of the system components.

[0069] The system has been successfully employed for drying different kinds of heat-sensitive materials, in particular a pasty foodstuff with moisture content of 60-80%, a liquid detergent, and an emulsion of an organic adhesive. The feed in its initial liquid state was supplied from a container, the temperature of which was 20-30 °C; feed rate was in the range of 5-10 l/h. The feed was atomized, by means of an ultrasonic oscillator with nozzle tip, into fine droplets with a diameter of 30-70 µm (microns) and dried at a reduced pressure of 133 millibar (100 torr) at 50 °C. The pump output of 10 l/sec was enough to maintain the required level of reduced pressure. After several fractions of a second of drying time, the dried product, in powder form, at 10 microns particle size and with negligible residual moisture content, was collected in the bag collector.

[0070] With reference to Figs. 3,4, an embodiment of the present invention will now be explained. As can be seen, this embodiment comprises basically similar components as the system shown in Figs. 1 and 2.

[0071] The feed is supplied from container 1 by means of a feed pump (not shown) via piping line 4, directly towards the horn portion of the ultrasonic oscillator 50, which receives ultrasonic vibrations from the generator 51. The atomized spray is accelerated by the nozzle, enters the auxiliary heating compartment 100 and then proceeds further into the heating chamber 10. The bottom portion of the chamber communicates via the sliding gate with collecting and recovery means. An evacuation means 40 maintains the required level of reduced pressure inside the chamber. The vapour generated during evaporation of the fluid media is exhausted from the bottom extremity of the chamber by

virtue of the same evacuation means 40, driving it off via piping line 34.

[0072] At least one hollow tubular element 80 is mounted close to the cylindrical wall 20 of the heating chamber. As shown in Fig. 4a it is substantially formed as a closed tube extending along the wall and provided with a plurality of openings 81, which enable communication of the interior of the heating chamber with the interior of the tube. The tube is manufactured from a heat resistant material capable of withstanding working temperatures, developed in the heating chamber and extending outside of the chamber via the appropriate outlet port, arranged adjacent to the bottom extremity 23 of the chamber. The outside end of the tube is connected with a collecting and recovery modular unit 250', formed similarly to modular unit 250 and comprising sliding gate 25', collecting means 26', and condenser 31'. The outlet port 33' connects unit 250' with evacuation means 40 via regulating valve 34' and piping line 34 so as to provide reduced pressure inside the tubular element, sweeping off part of the vapour generated during evaporation of the spray.

[0073] The purpose of the openings in the tubular element is to arrange for sweeping off of the vapour in a tangential direction along the entire length of the drying chamber.

[0074] The size and geometry of these openings as well as the cross-sectional configuration of the tubular element is chosen so as to ensure efficient driving off of the vapour produced at every step of the drying process and in every zone of the chamber.

[0075] By virtue of the above tubular element which provides a sweeping of the vapour in tangential direction, the main part of the vapour, moving in longitudinal direction and driven off via the bottom part of the chamber, moves more slowly, and therefore it becomes possible to increase residence time of material in the drying chamber and to ensure achieving the desired residual moisture content.

[0076] The other advantage associated with providing of the heating chamber with a sweeping means is the possibility of controlling the length of the central hot zone more efficiently in accordance with the properties of the particular material dried in the system

[0077] In order to increase the efficiency of the sweeping action, it might be advantageous to provide the system with several tubular elements distributed along the inner wall of the heating chamber and arranged in a jacket which is connected to a vacuum pump via an additional collecting and recovery means.

[0078] The regulating valve 34' is connected with the control means 60 so as to provide coordinated functioning of sweeping means 80 with additional components of the drying system.

[0079] As shown in Figs. 4a,b the tubular elements 80 might be provided with shields 82, mounted adjacent to openings 81. The purpose of these shields is to direct the driven-off vapour along the trajectory shown by

arrows in Fig. 4a towards openings 81, and to ensure that most of the dried particles become separated from the vapour and move towards the bottom extremity of the heating chamber.

[0080] By virtue of the above described system, efficient drying of a wide range of heat sensitive materials is ensured, at reduced temperatures, without deterioration of the properties of the dried product and up to a desired residual moisture.

Claims

1. Apparatus for drying wet material constituting a solid phase distributed in a fluid medium by means of evaporation of said medium, said apparatus comprising:

a feeding means (4) adapted to supply said material in liquid state into the system, e.g. in the form of a solution, suspension, dispersion, or prepared from a paste, slurry, sludge, a means of atomisation (5, 50, 51, 52) adapted to spray the supplied liquid material so as to convert its initial state into a mist consisting of a plurality of droplets,

an indirectly heated chamber (2) adapted to evaporate the fluid medium from said mist of droplets generated by said means of atomisation,

a product collecting means (250) adapted to collect the solid particles of the final dried product, produced from said wet material,

recovery means to recover said fluid medium from its evaporated state,

a vacuum pump (40) communicating with the interior of said heating chamber (2), adapted to maintain reduced pressure in the interior of said heating chamber so as to evaporate said fluid medium at temperatures lower than needed for its evaporation at normal pressure, and to evacuate, from the heating chamber, the moisture vapour generated during evaporation of said fluid media,

the heating chamber (2) being formed as an elongated compartment provided with vertical side walls (20) and having top and bottom extremities, said atomisation means (5) being mounted adjacent to the top extremity of said chamber (2), said recovery and product collecting means (250) being mounted adjacent to the bottom extremity of said chamber, characterised in that said product collecting means (250, 250') comprises a collecting bag or cyclone system and said vacuum pump (40) communicates with the interior of said heating chamber (2) through said collecting bag or through said cyclone system, said recovery means to recover said fluid medium including means (31)

- connected between said vacuum pump and said product collecting means (250), and in that a vapour sweeping means is provided formed as a hollow tubular element (80) mounted within said heating chamber and extending longitudinally close to the wall of the heating chamber, said tubular element (80) being connected with said vacuum pump (40), the hollow tubular element (80) being provided with a plurality of openings (81) providing communication between the interior of the heating chamber (2) and the interior of said tubular element (80), whereby part of the vapour generated within the heating chamber (2) during evaporation of the spray can be swept off through said tubular element (80), the apparatus including display and control means provided with appropriate sensors and instrumentation to control process variables.
2. Apparatus as claimed in claim 1, characterised in that said atomisation means is formed as an ultrasonic oscillator (50) consisting of a nozzle connected to a generator (51) of ultrasonic vibrations and said nozzle is provided with an elongated horn portion (52) which applies vibratory motion at the free end (53) thereof to the liquid material supplied by said feeding means (4).
 3. Apparatus as claimed in claim 2, characterised in that said oscillator (50) is mounted at the top extremity of said heating chamber (2), said elongated horn portion (52) being oriented parallel to the longitudinal axis of the heating chamber (2).
 4. Apparatus as claimed in claim 2, characterised in that it is provided with an auxiliary heating compartment (2') located at the upper end of said heating chamber, communicating therewith and extending radially with respect to the heating chamber, said atomisation means (5) being arranged to direct said spray into said auxiliary heating compartment (2') to pass from the auxiliary heating compartment (2') to the heating chamber, said oscillator (50) being so mounted that said elongated horn portion (52) of said nozzle is slanted with respect to the longitudinal axis of the heating chamber.
 5. Apparatus as claimed in claim 2, characterised in that said feeding means (4) supplies the liquid material from the outside to the free end of said horn portion (52).
 6. Apparatus as claimed in claim 2 characterised in that said feeding means supplies the liquid material via said oscillator (50) to the free end of said horn portion (52).

7. Apparatus as claimed in claim 1 wherein a further product recovery and collecting means 250' is connected between said vapour sweeping means (80) and said vacuum pump (40).
8. A system as defined in claim 1, characterised in that said vapour sweeping means (80) is formed with a plurality of shields (82), mounted on the outwardly facing surface of said hollow tubular element (80) in the vicinity of said openings (81) so as to provide a separation of particles of the final product from the vapour generated during evaporation and driven off by said sweeping means via said openings.

Patentansprüche

1. Vorrichtung zur Trocknung feuchten Materials, das aus einer festen Phase, welche in einem flüssigen Medium verteilt ist, besteht, durch ein Mittel zur Verdampfung besagten Mediums, wobei besagte Vorrichtung umfaßt:

ein Mittel zur Beschickung (4), welches so angepaßt ist, daß besagtes Material im flüssigen Zustand in das System zugeführt wird, z.B. in Form einer Lösung, Suspension, Dispersion, oder hergestellt aus einer Paste, einer Aufschlämmung, einem Schlamm,

ein Zerstäubungsmittel (5, 50, 51, 52), welches so angepaßt ist, daß das zugeführte flüssige Material so versprüht wird, daß sein Anfangszustand in einen leichten Nebel, welcher aus einer Vielzahl von Tröpfchen besteht, umgewandelt wird,

eine indirekt beheizte Kammer (2), die so angepaßt ist, daß das flüssige Medium von besagtem Tröpfchennebel, welcher durch besagtes Zerstäubungsmittel erzeugt wird, verdampft wird,

ein Mittel zur Sammlung des Produktes (250), das so angepaßt ist, daß die festen Partikel des endgetrockneten Produktes, welches aus besagtem feuchten Material hergestellt wird, gesammelt werden,

Wiedergewinnungsmittel zum Wiedergewinnen besagten flüssigen Mediums aus seinem Dampfzustand,

eine Vakuumpumpe (40), die mit besagter Heizkammer (2) in Verbindung steht und so angepaßt ist, daß ein reduzierter Druck im Inneren besagter Heizkammer so aufrechterhalten wird, daß besagtes flüssiges Medium

bei niedrigeren Temperatur n, als bei seiner Verdampfung bei Normaldruck erforderlich sind, verdampft wird, und daß der Feuchtigkeitsdampf, der während des Verdampfens besagten flüssigen Mediums erzeugt wird, aus der Heizkammer abgesaugt wird,

wobei die Heizkammer (2) als eine längliche Kammer ausgebildet geformt ist, welche mit vertikalen Seitenwänden (20) versehen ist und obere und untere äußerste Enden aufweist, besagtes Zerstäubungsmittel (5) angrenzend an das obere äußerste Ende besagter Kammer (2) angebracht ist, besagte Wiedergewinnungsmittel und Mittel zur Sammlung des Produktes (250) angrenzend an das untere äußerste Ende besagter Kammer angebracht sind, dadurch gekennzeichnet, daß besagtes Mittel zur Sammlung des Produktes (250, 250') einen Sammelbeutel oder ein Zyklonsystem umfaßt und besagte Vakuumpumpe (40) mit dem Inneren besagter Heizkammer (2) durch besagten Sammelbeutel oder besagtes Zyklonsystem in Verbindung steht, wobei besagtes Wiedergewinnungsmittel zum Wiedergewinnen besagten flüssigen Mediums Mittel (31) einschließt, die zwischen besagter Vakuumpumpe und besagtem Mittel zur Sammlung des Produktes (250) verbunden sind, und daß ein Mittel zur Abführung des Dampfes bereitgestellt ist, welches, als ein hohles röhrenförmiges Element (80) ausgebildet, innerhalb besagter Heizkammer angebracht ist und sich longitudinal eng an der Wand der Heizkammer entlang erstreckt, wobei röhrenförmiges Element (80) mit besagter Vakuumpumpe (40) verbunden ist, das hohle röhrenförmige Element (80) mit einer Vielzahl an Öffnungen (81) bereitgestellt ist, welche eine Verbindung zwischen dem Inneren der Heizkammer (2) und dem Inneren besagten röhrenförmigen Elements (80) bereitstellen, wodurch ein Teil des Dampfes, welcher innerhalb der Heizkammer (2) erzeugt wird, während des Verdampfens der Sprühflüssigkeit durch besagtes röhrenförmiges Element (80) abgeführt werden kann, wobei die Vorrichtung Anzeige- und Kontrollmittel einschließt, welche mit geeigneten Sensoren und Instrumentarium zur Kontrolle der Prozeßvariablen versehen sind.

2. Vorrichtung nach Anspruch 1, dadurch gekennzeichnet, daß besagtes Zerstäubungsmittel als Ultraschalloszillator (50) gebaut ist, der aus einer Düse, die mit einem Erzeuger (51) von Ultraschallschwingungen verbunden ist, besteht, und besagte Düse mit einem länglichen Schalltrichterabschnitt

versehen ist, welcher an seinem freien Ende (53) das flüssige Material, welches durch besagtes Mittel zur Beschickung (4) zugeführt wird, mit Schwingungsbewegung beaufschlagt.

3. Vorrichtung nach Anspruch 2, dadurch gekennzeichnet, daß besagter Oszillator (50) am oberen äußersten Ende besagter Heizkammer (2) angebracht ist, wobei besagter länglicher Schalltrichterabschnitt (52) parallel zur Längsachse der Heizkammer (2) ausgerichtet ist.
4. Vorrichtung nach Anspruch 2, dadurch gekennzeichnet, daß diese mit einer Hilfsheizkammer (2') versehen ist, welche sich am oberen Ende besagter Heizkammer befindet, damit in Verbindung steht und sich radial bezüglich der Heizkammer erstreckt, wobei besagtes Zerstäubungsmittel (5) so angeordnet ist, daß besagte Sprühflüssigkeit in besagte Hilfsheizkammer (2') gelenkt wird, um von der Hilfsheizkammer (2') zur Heizkammer (2) zu gelangen, wobei besagter Oszillator (50) so angebracht ist, daß besagter Schalltrichterabschnitt (52) besagter Düse in Bezug auf die Längsachse der Heizkammer geneigt ist.
5. Vorrichtung nach Anspruch 2, dadurch gekennzeichnet, daß besagtes Mittel zur Beschickung (4) das flüssige Material von der Außenseite zum freien Ende besagten Schalltrichterabschnitts (52) zuführt.
6. Vorrichtung nach Anspruch 2, dadurch gekennzeichnet, daß besagtes Mittel zur Beschickung das flüssige Material über besagten Oszillator (50) zum freien Ende besagten Schalltrichterabschnitts (52) zuführt.
7. Vorrichtung nach Anspruch 1, bei der ein weiteres Wiedergewinnungsmittel und Mittel zur Sammlung des Produktes (250') zwischen besagtem Mittel zur Abführung des Dampfes (80) und besagter Vakuumpumpe (40) verbunden ist.
8. Ein System nach Anspruch 1, dadurch gekennzeichnet, daß besagtes Mittel zur Abführung des Dampfes mit einer Vielzahl von Schilden (82) ausgebildet ist, die an der nach außen zeigenden Oberfläche besagten hohlen röhrenförmigen Elements (80) in der Nähe besagter Öffnungen (81) so angebracht sind, daß eine Trennung der Partikel des Endproduktes vom Dampf, welcher während der Verdampfung erzeugt und durch besagte Mittel zum Abführen über besagte Öffnungen abgeführt wird, bereitgestellt wird.

Revendications

1. Dispositif pour sécher un matériau humide constituant une phase solide distribuée dans un milieu fluide au moyen d'une évaporation dudit milieu, ledit dispositif comprenant :

un moyen d'alimentation (4) conçu pour délivrer ledit matériau à l'état liquide dans le système, par exemple, sous la forme d'une solution, d'une suspension, d'une dispersion ou préparé à partir d'une pâte, d'une suspension, d'une boue,

un moyen d'atomisation (5, 50, 51, 52) conçu pour pulvériser le matériau liquide délivré de façon à convertir son état initial en un brouillard qui est constitué d'une pluralité de gouttelettes, une chambre indirectement chauffée (2) conçue pour faire évaporer le milieu fluide à partir dudit brouillard de gouttelettes généré par ledit moyen d'atomisation,

un moyen de collecte de produit (250) conçu pour collecter les particules solides du produit séché final, produites à partir dudit matériau humide,

un moyen de récupération pour récupérer ledit milieu fluide à partir de son état évaporé, une pompe à vide (40) communiquant avec l'intérieur de ladite chambre de chauffage (2), conçue pour maintenir une pression réduite à l'intérieur de ladite chambre de chauffage de façon à faire évaporer ledit milieu fluide à des températures inférieures à celles nécessaires pour son évaporation à une pression normale et pour évacuer, à partir de la chambre de chauffage, la vapeur d'humidité générée pendant l'évaporation desdits milieux fluides, la chambre de chauffage (2) étant formée comme un compartiment allongé muni de parois latérales verticales (20) et ayant des extrémités supérieure et inférieure, ledit moyen d'atomisation (5) étant monté adjacent à l'extrémité supérieure de ladite chambre (2), ledit moyen de récupération et ledit moyen de collecte de produit (250) étant montés adjacents à l'extrémité inférieure de ladite chambre, caractérisé en ce que ledit moyen de collecte de produit (250, 250') comprend un sac de collecte ou un système de type cyclone et ladite pompe à vide (40) communique avec l'intérieur de ladite chambre de chauffage (2) par l'intermédiaire dudit sac de collecte ou par l'intermédiaire dudit système de type cyclone, ledit moyen de récupération pour récupérer ledit milieu fluide incluant un moyen (31) raccordé entre ladite pompe à vide et ledit moyen de collecte de produit (250), et en ce qu'un moyen de balayage de vapeur est prévu, formé comme

un élément tubulaire creux (80) monté à l'intérieur de ladite chambre de chauffage et s'étendant longitudinalement à proximité de la paroi de la chambre de chauffage, ledit élément tubulaire (80) étant raccordé à ladite pompe à vide (40), l'élément tubulaire creux (80) étant muni d'une pluralité d'ouvertures (81) assurant la communication entre l'intérieur de la chambre de chauffage (2) et l'intérieur dudit élément tubulaire (80), d'où il résulte qu'une partie de la vapeur générée à l'intérieur de la chambre de chauffage (2) pendant l'évaporation de la pulvérisation peut être évacuée par l'intermédiaire dudit élément tubulaire (80), le dispositif incluant un moyen d'affichage et de commande muni de capteurs appropriés et d'instruments appropriés pour commander les variables du processus.

2. Dispositif selon la revendication 1, caractérisé en ce que ledit moyen d'atomisation est formé comme un oscillateur à ultrasons (50) qui est constitué d'une buse raccordée à un générateur (51) de vibrations à ultrasons et ladite buse est munie d'une partie de cornet allongé (52) qui applique un déplacement vibratoire à son extrémité libre (53) au matériau liquide délivré par ledit moyen d'alimentation (4).
3. Dispositif selon la revendication 2, caractérisé en ce que ledit oscillateur (50) est monté à l'extrémité supérieure de ladite chambre de chauffage (2), ladite partie de cornet allongé (52) étant orientée parallèle à l'axe longitudinal de la chambre de chauffage (2).
4. Dispositif selon la revendication 7, caractérisé en ce qu'il est muni d'un compartiment de chauffage auxiliaire (2') placé à l'extrémité supérieure de ladite chambre de chauffage, communiquant avec celle-ci et s'étendant radialement par rapport à la chambre de chauffage, ledit moyen d'atomisation (5) étant disposé pour diriger ladite pulvérisation dans ledit compartiment de chauffage auxiliaire (2') pour passer du compartiment de chauffage auxiliaire (2') à la chambre de chauffage, ledit oscillateur (50) étant monté de sorte que la partie de cornet allongé (52) de ladite buse est inclinée par rapport à l'axe longitudinal de la chambre de chauffage.
5. Dispositif selon la revendication 2, caractérisé en ce que ledit moyen d'alimentation (4) délivre le matériau liquide provenant de l'extérieur à l'extrémité libre de ladite partie de cornet (52).
6. Dispositif selon la revendication 2, caractérisé en ce que ledit moyen d'alimentation délivre le maté-

riau liquide *via* ledit oscillateur (50) à l'extrémité libre de ladite partie de cornet (52).

7. Dispositif selon la revendication 1, dans lequel un autre moyen de récupération de collecte de produit (250') est raccordé entre ledit moyen de balayage de vapeur (80) et ladite pompe à vide (40). 5
8. Système comme défini dans la revendication 1, caractérisé en ce que ledit moyen de balayage de vapeur (80) est formé avec une pluralité de protections (82), montées sur la surface dirigée vers l'extérieur dudit élément tubulaire creux (80) au voisinage desdites ouvertures (81) de façon à procurer une séparation des particules du produit final à partir de la vapeur générée pendant l'évaporation et entraînée à l'extérieur par ledit moyen de balayage *via* lesdites ouvertures. 10 15

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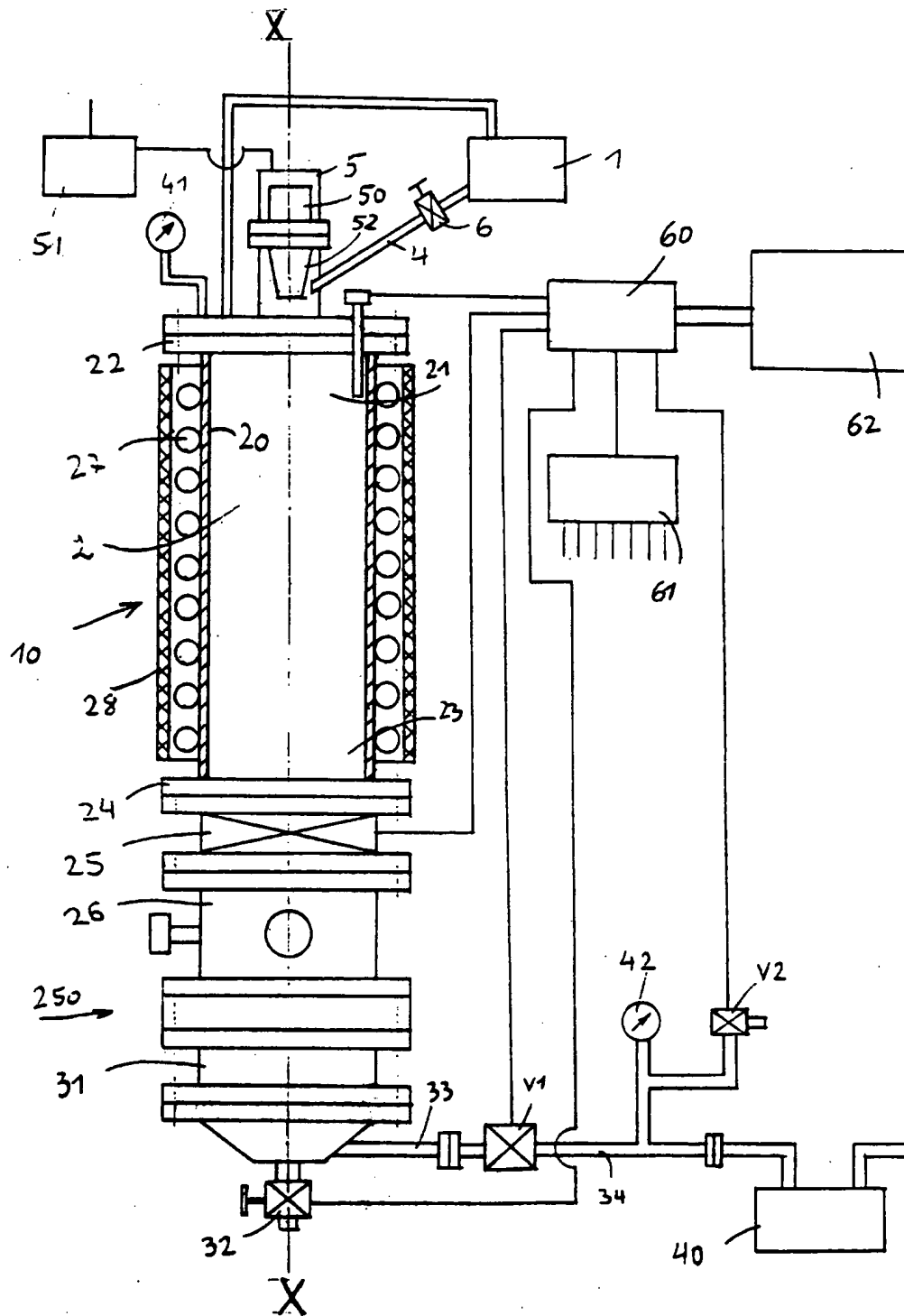
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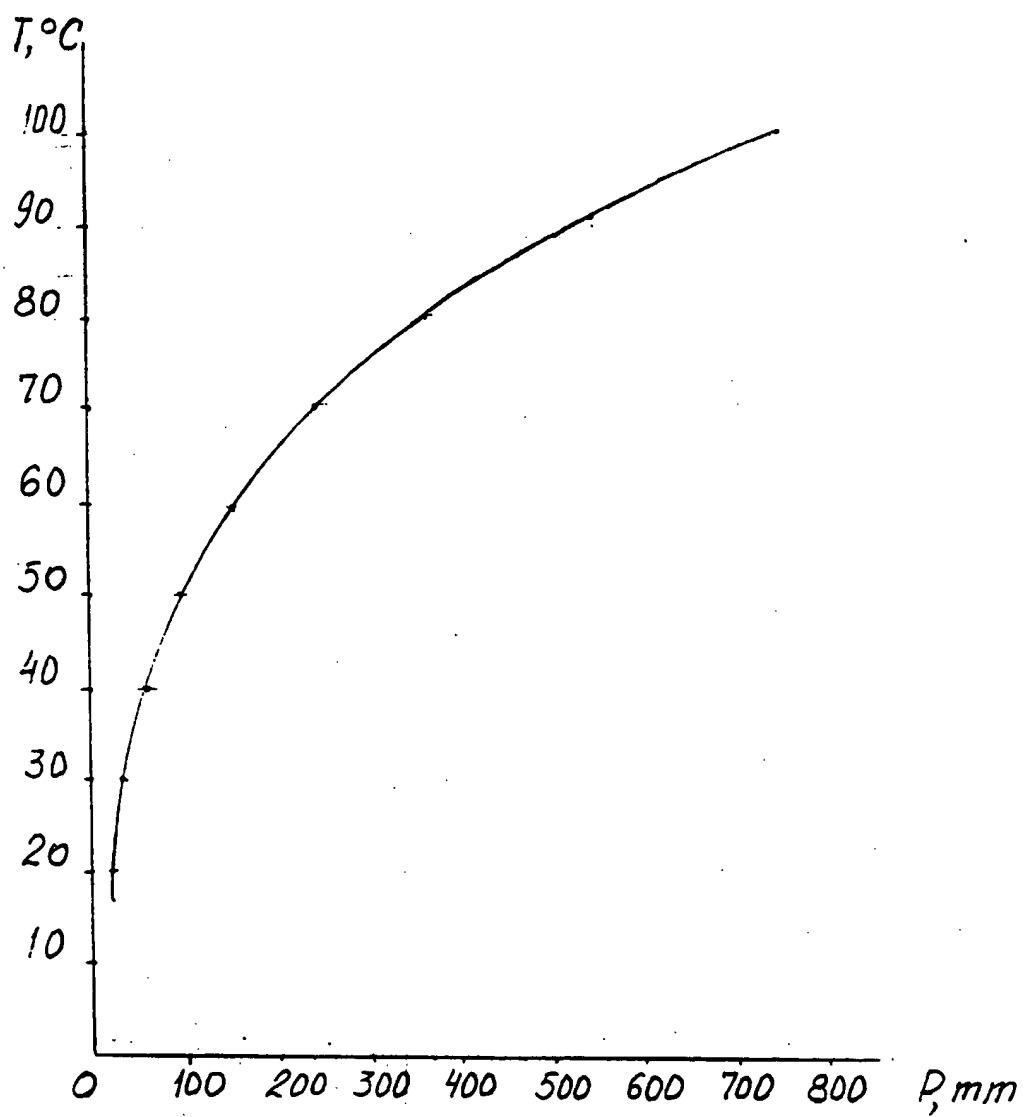


Fig. 18

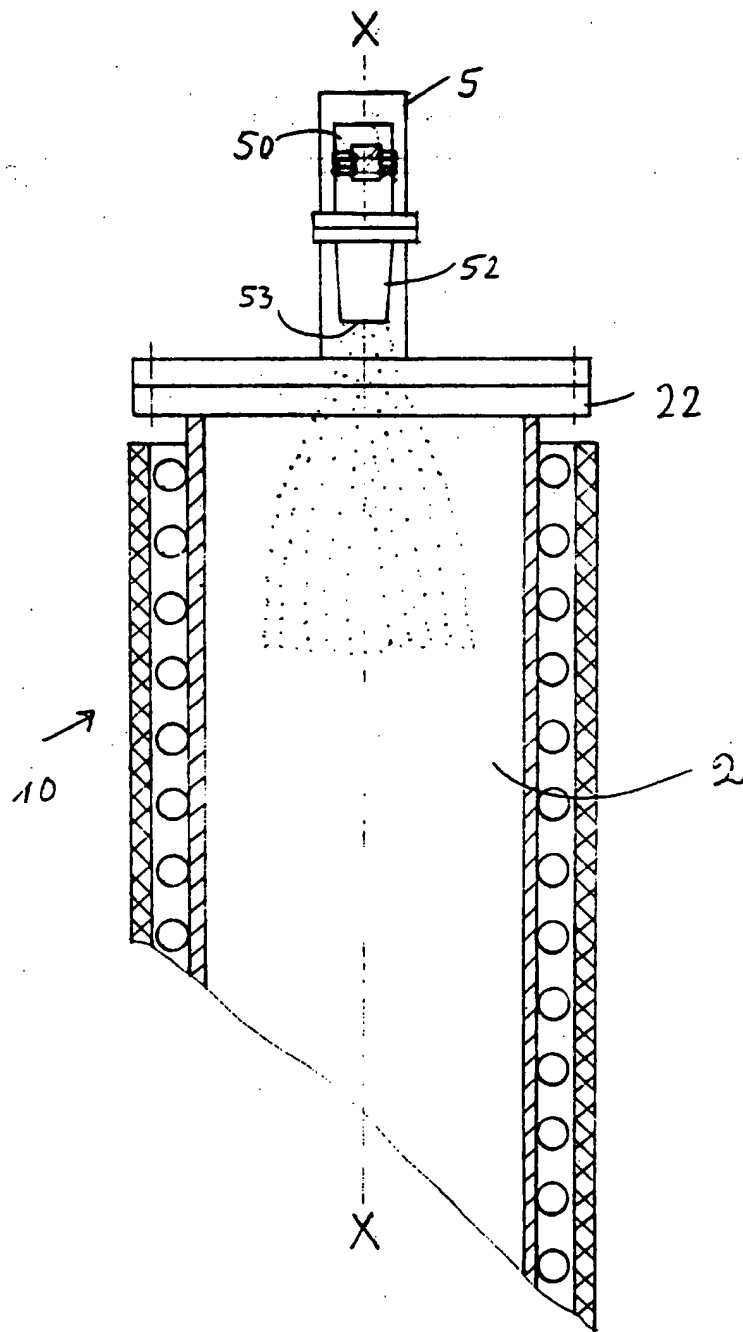


Fig. 2a

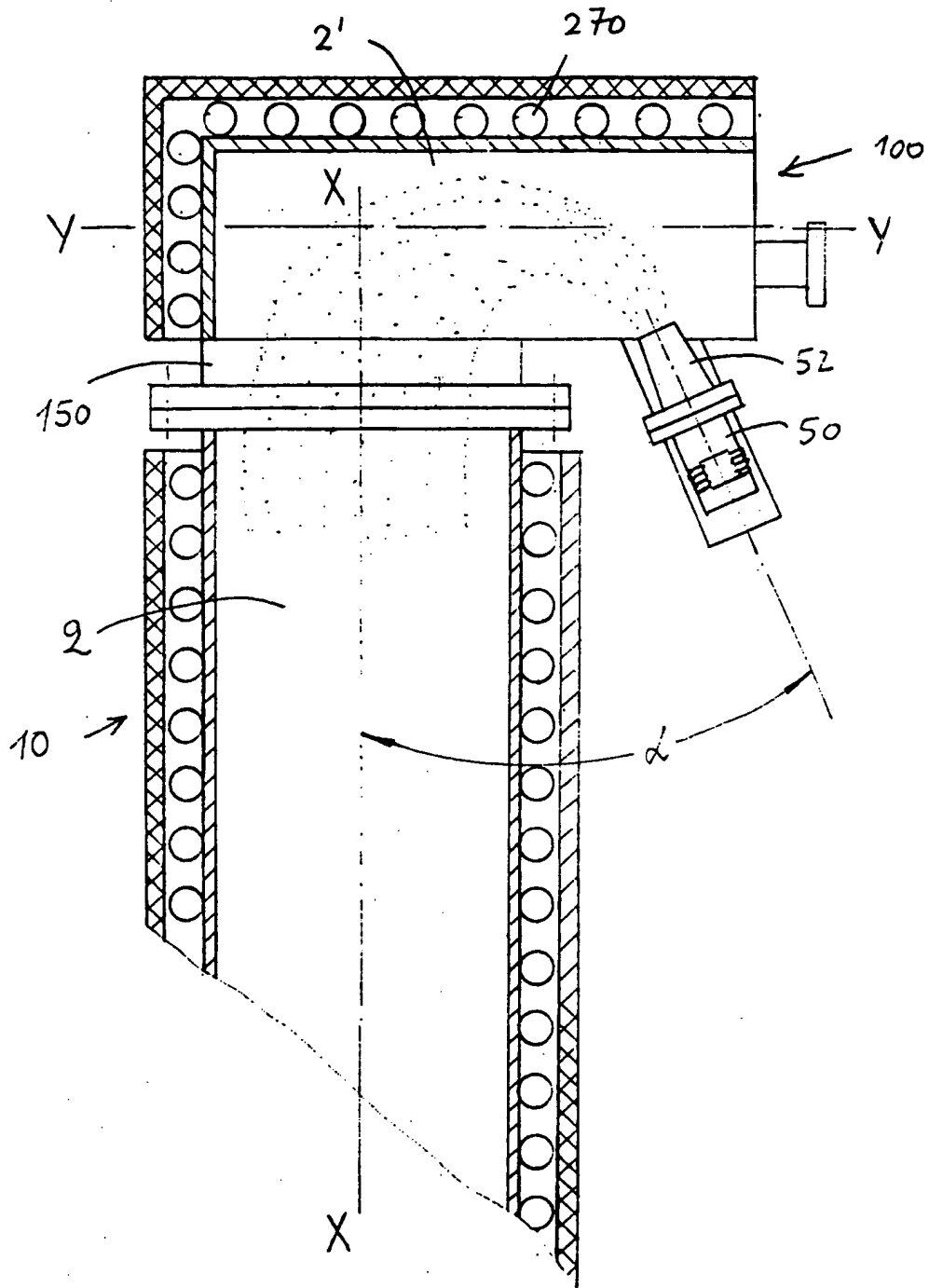


Fig 26

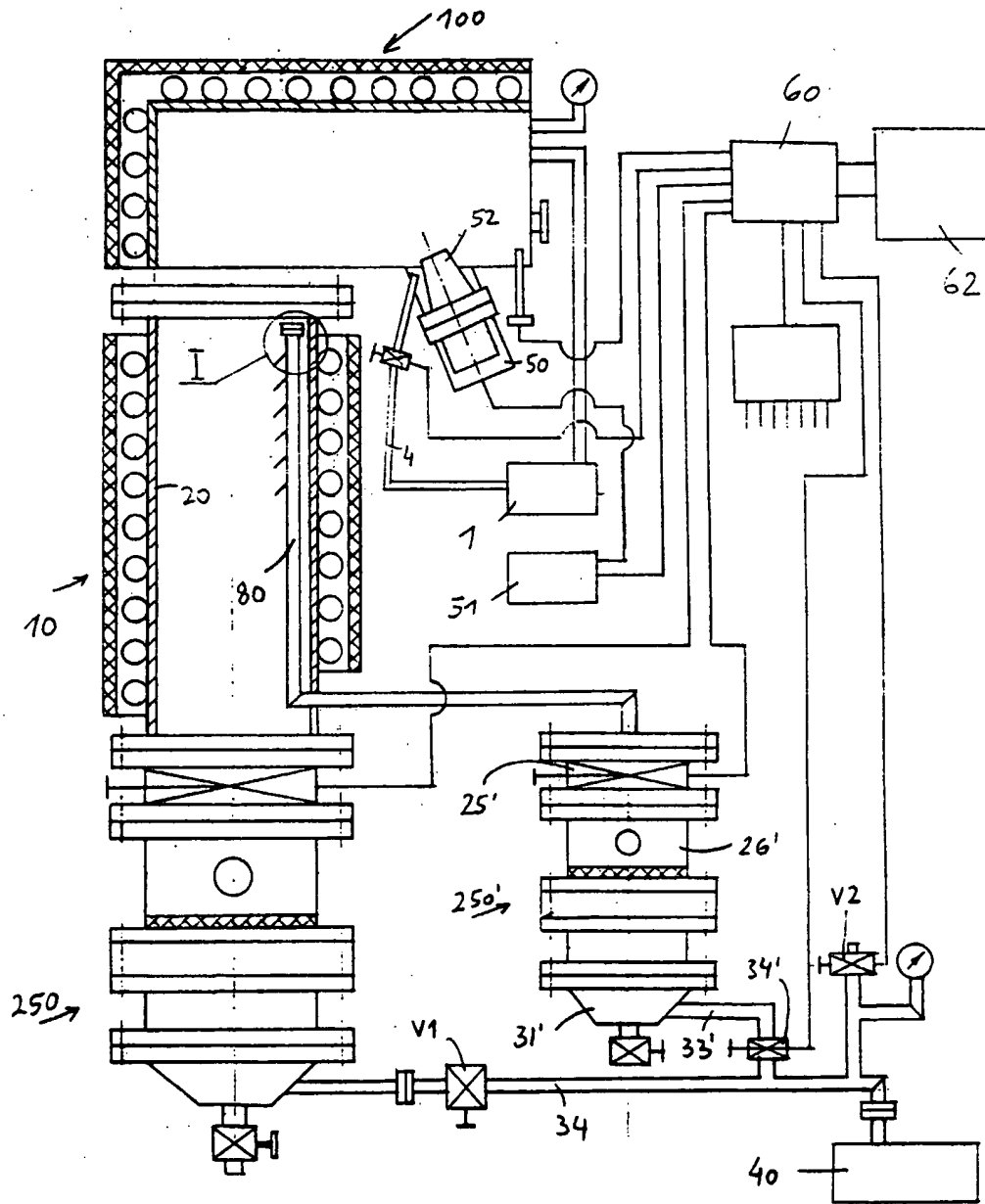


Fig. 3

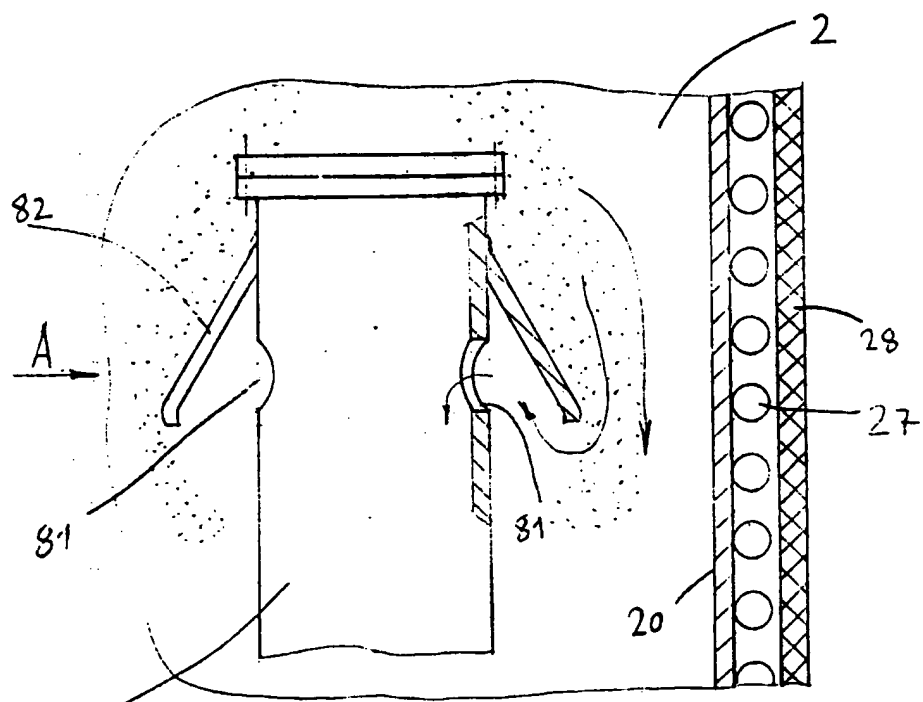


Fig. 4a

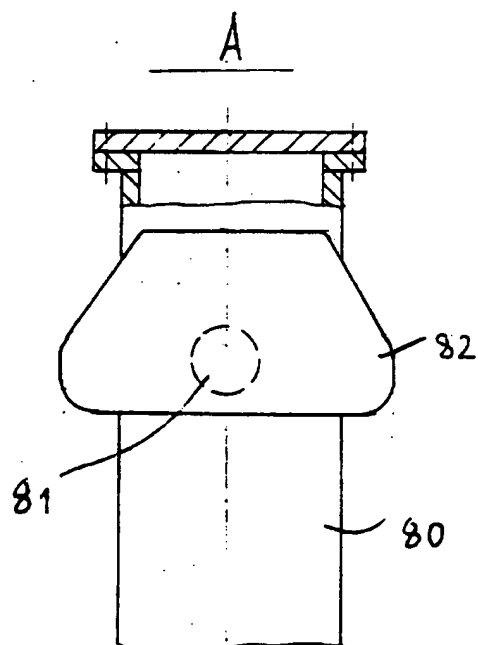


Fig. 4b